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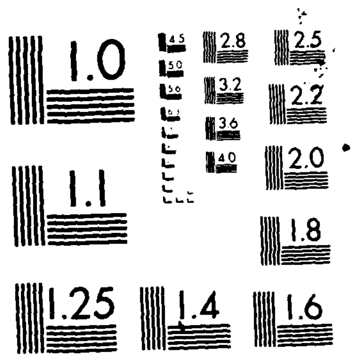

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Report No. CG-D-17-86

Coast Guard High Frequency SITOR and Digital Selective Callin[g] Operational Review and Implementation Plan

Prepared for:

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16. Abstract

The areas of increased SITOR communications and the effects of Digital Selective Calling (DSC) on Coast Guard communications primarily in distress frequency guarding are studied. To determine how SITOR might be utilized for Coast Guard communications and how its use with merchant vessels could be expanded, the communications capabilities of Coast Guard cutters and a Communications Station are briefly described. The potential uses of SITOR on cutters are then discussed and the cost benefits that might be realized by increasing SITOR and DSC use between merchant vessels and Communications Stations rather than HF CW are indicated. A test plan for SITOR communications and DSC operations in the Fourteenth Coast Guard District is provided for a lateFiscal Year 1986 test.

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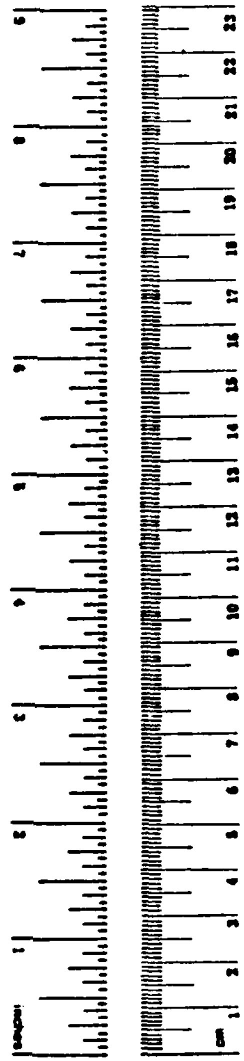
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

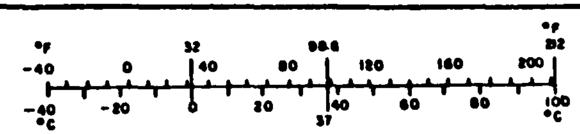
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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Coast Guard High Frequency SITOR
and
Digital Selective Calling
Operational Review and ~~Test~~ IMPLEMENTATION Plan

by

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN TELECOMMUNICATIONS SYSTEMS MANAGEMENT

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ABSTRACT

The areas of increased SITOR communications and the effects of Digital Selective Calling (DSC) on Coast Guard Communications primarily in distress frequency guarding are studied. To determine how SITOR might be utilized for Coast Guard communications and how its use with merchant vessels could be expanded, the communications capabilities and functions of the major classes of Coast Guard cutters and a Communications Station are briefly described. The potential uses of SITOR on cutters are then discussed and the cost benefits that might be realized by increasing SITOR use between merchant vessels and Communication Station rather than HF CW is indicated. A test plan for SITOR communications and DSC operations in the Fourteenth Coast Guard District is provided for a late Fiscal Year 1986 test.

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I. INTRODUCTION

The only modes of radioteletype (RATT) and continuous wave (CW) communications between Coast Guard Communications Stations and their users is in the medium and high frequency (MF and HF) spectrum (.3-30) megahertz (mHz). Primary users consist of Coast Guard Cutters and Aircraft, U.S. Navy ships, other Government Ships, and merchant vessels of the world. Coast Guard Communications Stations also are the primary locations for guarding the maritime distress frequencies, 500 kilohertz (kHz) CW and 2182 kHz voice.

Guarding of distress frequencies, in particular 500 kHz, is a job that requires vigilance, alertness, and careful listening as distress calls come in at random times and may be extremely weak. To simplify the discussion in this thesis, the abbreviation HF will include all MF frequencies also.

During the last several years, tests and studies concerning the use of Digital Selective Calling (DSC) as a replacement for live, dedicated frequency monitoring, have been carried out extensively in the North Sea area, and to a lesser extent worldwide including the United States and Guam [Ref. 1:p. 4-9]. Results have been encouraging, and The International Maritime Organization (IMO) is recommending that DSC be the only method of distress and safety calling

in the Future Global Maritime Distress and Safety System [Ref. 2:p. 177]. Consequently, watchkeeping requirements on 500 kHz, 2182 kHz, and VHF-FM channels will be eliminated and replaced by automated DSC distress calling and safety alerting systems by the late 1990s.

HF communications with non-Coast Guard vessels at sea is a primary mission of Coast Guard Communications Stations. Whether it is a weather broadcast, position report or other type message, each Communications Station sends and receives thousands of record messages each year. As an example, from July 1985 through December 1986 Communications Stations San Francisco, Honolulu, and Guam together sent and received a total of 103,881 messages on HF CW or Simplex Teleprinting Over Radio (SITOR) to merchant vessels. Watchstanders are dedicated to the SITOR and HF CW positions at each Communications Station.

This thesis has four main sections. Chapter II is a description of the operational and technical characteristics of DSC and SITOR. The DSC technical and call sequence formats are identified and described, and the three SITOR modes of communications are explained.

Chapter III describes HF and other RATT capabilities of each major class of Coast Guard Cutter and a Communications Station. The chapter is designed to provide the reader with a basic understanding of each type unit and the watch requirements of the attached radiomen. Communications

equipment onboard and the number of radiomen assigned to each unit is addressed, as are tasks and functions of those radiomen.

Chapter IV discusses the potential uses of SITOR communication systems on Coast Guard cutters and the possible personnel costs savings associated with the elimination of HF CW circuits at Communications Stations. The chapter also presents ideas on how the implementation of DSC distress calling and safety alerting will impact cutters and Communications Stations.

Chapter V is a proposed plan for SITOR and DSC testing scheduled to take place in the 14th Coast Guard District late in Fiscal Year 86. The test units are a long range Buoy Tender (WLB) and Communications Station Honolulu. It is hoped that the results will indicate that it is feasible for cutters without manned radio rooms to receive record message traffic at any time by using SITOR, and the dependability of DSC. The plan, developed in association with the 14th District, concentrates on procedures, data gathering, and the analysis of that data. The major technical matters and personnel training will be addressed by the 14th District once the equipment is received.

Finally, in summarizing the thesis the author will offer some conclusions, recommendations, and suggestions concerning the systems discussed.

II. DIGITAL SELECTIVE CALLING (DSC) CHARACTERISTICS

This chapter discusses the general operational and technical characteristics for a digital selective calling system, and describes the DSC modes used in Coast Guard high frequency (HF) radioteletype (RATT) communications with merchant ships and possibly in the future on Coast Guard cutters.

A. OPERATIONAL CHARACTERISTICS

The digital selective calling sequence format consists of the format specifier, address information, category information, self identification block, message area(s), and the end of sequence block. The call sequence format is displayed in Figure 1.

format specifier	address	category	self-identification

message 1	message 2	....	end of sequence

Figure 1. Call Sequence Format

A typical DSC call consists of the transmitting station sending out a call sequence in the format of Figure 1. The receiving station acknowledges receipt of the signal

and then shifts to an appropriate working frequency specified in one of the message areas if subsequent communications are necessary [Ref. 2:p. 182].

1. Call Sequences Types

There are three types of call sequences; distress calls, calls other than distress, and replies to or acknowledgments of one of those calls. The distress call provides for alerting, self identification, ship's position and time, and nature of distress. Specifics of those items will be addressed in paragraph A.1.e. [Ref. 3:p. 2]. Calls other than distress and safety require the use of international or national channels. National channels should always be used between ships and coastal stations for administrative type calls [Ref. 4:p. 2]. The third type of call sequence is an acknowledgment from the called station that the message was received.

2. Digital Selective Call Sequence

a. Format Specifier

The format specifier indicates for whom the call is destined. It could be a distress call, an all ships call or a selective call. A distress call is just that, a call from a ship in distress or a distress call relay, which would go to all units and stations guarding that distress channel. An all ships call might be a weather or safety broadcast, while a selective call could be to an individual

ship, a group of ships or stations having a common interest, or all ships in a particular geographic area [Ref. 4:p. 2].

b. Address

The address block concerns calls other than distress and all ships calls since the address for those types is contained in the format specifier block. For other type calls the address block contains the unique identifier of a specific ship or station, that of a group of related ships or the identifier of a specific geographic area.

c. Category

The category block defines the degree of priority of the call. There are six categories:

(1) Distress--contained in the format specifier.

(2) Urgency

(3) Vital Safety

(4) Important Safety

(5) Ship's business, priority--a call authorized by the ship's owner or agent requiring immediate handling on the ship.

(6) Routine

d. Self identification

This block is the unique selective call (selcall) identifier of the calling station. The International Telecommunications Union (ITU) assigns selcall numbers.

e. Messages

Message elements vary as to the type. Distress messages consist of four elements in the following sequence:

(1) Nature of distress

(2) Position of distress

(3) Time of the position

(4) An indication of the type of communication desired by the station in distress for subsequent exchange of information such as CW or voice.

Non-distress messages are limited to three message elements per call sequence. A message element is an information block coded in accordance in with the tables proposed in IMO recommendation 493-2(MOD I) and will normally be used to provide subsequent communication directions to the receiving station [Ref. 2:p. 184].

f. End of sequence

This element is one of three unique signals that signals the end of a call. It either requires a call acknowledgment, indicates it was a call acknowledgment, or categorizes it as "other calls".

B. TECHNICAL CHARACTERISTICS

1. Call Sequence Technical Format

The technical format of a typical call sequence is displayed in Figure 2. This format parallels the operational characteristics format with the addition of a

dot pattern, phasing sequence, and error checking characteristic. The number in the lower half of each block indicates the number of characters it contains.

a. Dot Pattern

The dot pattern precedes the phasing sequence to allow for the use of scanners for MF or HF frequencies. Dot patterns are not included in acknowledgments from receiving stations and ships are to use the dot pattern only if calling ship to ship, or prior to a distress call. The dot pattern is of two seconds duration [Ref. 2:p. 185].

Dot pattern	DX/RX Phasing sequence	Format specifier 2 symbols	Called party address 5 symbols	Category 1 symbol

Self ident 5 sym	Telecommand message 2 symbols	Frequency message 3 symbols	Frequency message 3 symbols	End of sequence 3 symbols	Error check char 1 symbol

Figure 2. Call Sequence Technical Format

b. Phasing Sequence

The phasing signal provides information to the receiver to permit correct bit phasing and unambiguous determination of the position of the signal within the call sequence. During the phasing sequence, specific signals in the sending and receiving stations are transmitted

alternately. Synchronization between the receiver and transmitter is achieved by symbol recognition rather than a change in dot pattern. This is to reduce false synchronization caused by a bit error in the dot pattern [Ref. 2:p. 185].

c. Error-Check Character

The error check character is the final character transmitted and checks the entire sequence for errors. It accomplishes this utilizing a ten unit error detecting code.

2. Error Detecting

The DSC system is a synchronous call with a ten unit error detecting code. The first seven bits are information bits in ASCII form and bits 8, 9, and 10 are used for error detecting. They are in binary form and their sum indicates the number of zeros appearing in the first seven bits. If those two numbers are not the same, an error is assumed to have occurred [Ref. 2: p. 183].

3. Time Diversity

Apart from the dot pattern and phasing signal, each signal is transmitted twice in a time spread mode. The effect of atmospheric propagation, other signals and collisions with other calls require this double transmission to insure proper reception. Transmission of the first signal is followed by the next four signals before the first is transmitted again. This necessitates a 400 millisecond

reception interval for frequencies in the MF and HF ranges [Ref. 2:p. 183].

4. Frequency Shifts and Modulation Rates

HF and MF frequencies utilize a frequency shift of 170 hertz at a 100 baud rate. When frequency-shift keying is effected by applying audio signals to the input of single sideband transmitter, the center of the audio-frequency at the transmitter is 1700 hertz [Ref. 5:p. 26].

C. OPERATIONAL MODES

There are three modes of transmitting messages with DSC equipment: Automatic Request for Transmission (ARQ), selective forward error control protocol (FEC), and collective FEC. ARQ requires an active link between the sending and receiving station, while FEC is similar to a broadcast, but can be sent to specific individual units, a specific group of units, or all units within copying range. These modes are more commonly known as SITOR and are used primarily with merchant vessels.

1. Automatic Request for Transmission

Transmission of messages in the ARQ mode is a very dependable, but slow method of ensuring a message reaches its destination. To initiate ARQ the sending station transmits the address or selective calling (selcall) identification of the desired unit. Selcall identification is a five digit number assigned by the International

Telecommunications Union for maritime use. The transmission will continue until a successful link is established or for about one minute when the transmitter will halt its attempts and wait for the operator to intervene and determine the next step. Upon achieving a successful link, the sending and receiving stations begin a rapid exchange of information. The transmitting station sends its text in three character groups. The receiving station "inspects" the groups and if it detects no errors it will request the next one. If an error is detected a request for retransmission is sent. Again, after about one minute, if the group has not been received correctly, it is skipped and the next one sent. A blank space or other symbol will appear in the message where the missing group was. Cumulative time for sending and receiving a confirmation on a three character group is about one second [Ref. 6:p. 4-25].

If propagation is such that no repetitions are necessary, transmission rate in the ARQ mode will be about 50 baud or 67 words per minute. After message transmission is complete the sending station will send a break communications signal that will revert both systems to standby [Ref. 6:p. 4-30].

2. Forward Error Correcting Protocol

The FEC mode can be defined as a broadcast with the ability to choose the recipients. There is no active error

correction feature, however each character is transmitted twice at 100 baud, and the receiving station chooses the best of the two symbols received. If both characters have taken "hits" a blank space or other appropriate symbol will be printed in that spot [Ref 6:pp. 4-29--4-31].

a. Collective FEC

Collective FEC enables the transmitting station to send messages to multiple unrelated units at the same time. Messages such as traffic summaries, weather broadcasts, and other all ship type texts could be sent in a collective FEC mode. Because of its broadcast mode, it should be used during good to excellent propagation conditions. Collective FEC does not use selcall identification codes [Ref. 6:p. 4-31].

b. Selective FEC

Selective FEC is a broadcast type transmission, but because of the use of selcall address the unit or units to whom it is received by can be controlled. All units with DSC equipment can receive the FEC broadcast, but only the units with the specified selcall for can decode and read the transmissions. Selective FEC is useful when propagation will not support ARQ, but the message needs to be sent even if received with some errors [Ref. 6:p. 4-31].

III. SELECTIVE COAST GUARD HF RATT CAPABILITIES

Coast Guard high frequency record message communications vary greatly between class of ship and type of shore station. This chapter will describe the functions, tasks, and HF capabilities of radio rooms on board WHEC-378s, WMEC-210s and 270s, WAGBs (Polar class), long range WLBs, and those of a Coast Guard Communications Station, utilizing Communications Station San Francisco as a basis. While it was not possible to visit or interview communications personnel at every unit in the Coast Guard, the ones that were visited and interviewed represent typical units of each class. Additionally, all but one of the units visited were in the Pacific Area, but from the author's personal experiences, their communications equipment, watchstanding techniques, and operational procedures are identical or very similar to Atlantic area cutters and stations of the same class. The WMEC-270 class was the only ship of interest not visited. All information concerning the capabilities and radio room operations of the units described in the next section was gathered during visits to or discussions with the units previously acknowledged, or from the author's personal experiences.

A. COAST GUARD CUTTER CAPABILITIES

Capabilities between the classes of cutters differ greatly. They range from only UNCLAS RATT on WLB's to multiple HF ORESTES and satellite capabilities on the Polar Class Icebreakers, while WMEC-210s and 270s, and WHEC-378s lie in between. Table 1 displays the numbers and types of transmitters, receivers, and transceivers available on the different class cutters, and Table 2 shows the different types of record message circuits available on each class.

It should be noted that these tables indicate individual system characteristics, and that other factors and limitations may preclude use of them simultaneously.

1. Long range WLB

The WLB-180s in the 14th Coast Guard District have limited RATT capabilities. They are capable of sending and receiving one UNCLAS or uncovered circuit. The loss of that circuit would leave them with no record message capability.

2. WMEC-210

WMEC-210s were the next least capable ship in the area of record message communications studied. They are capable of one ORESTES circuit and one unclassified (UNCLAS) circuit, or two UNCLAS circuits. The failure of their secure circuit would leave them without covered capability, and the failure of both would leave them without any record message capabilities.

TABLE 1 - COMMUNICATIONS EQUIPMENT

CUTTER CLASS / COMMS EQUIP (RATT or CW)	R-1Ø51B 1.6-3Ø MHZ HF RCV	NAVMACS XMT/RCV	WSC-3 XMT/RCV	SSR-1 RCV	AN/URT-23 2-30 MHZ HF XMT	GSB-9ØØ 1.6-3Ø MHZ HF XMT/RCV	COLLINS 651 .25-3Ø MHZ MF/HF RCV	WRR 3A/B 14-6ØØ KHZ LF/MF XM/RC	FRA-Ø1 5ØØKHZ RCV	AN/SRR-19 3Ø-3ØØKHZ VLF/LF RCV	AN/URC-9 Ø-4ØØMHZ UHF XMT/RCV
WAGB	X	X	X	X	X	X	X	X		X	X
WHEC-378	X		X	X	X	X	X	X	X	X	X
WMEC-270	HF-8050 RCV X	X	X		HF-80A XMT X						
WMEC-210	X				X	X	X		X		
WLB	X				X	X	X				

TABLE 2 - COMMUNICATION CIRCUITS

CUTTER CLASS \ CAPABILITIES		FLEET SATEL-LITE	HF ORESTES	HF UNCLAS	UHF ORESTES	UHF UNCLAS	LF	VLF	HF (CW)	
WAGB	SEND	X	X	X	X	X			X	
	RECEIVE	X	X	X	X	X	X	X	X	
WHEC-378	SEND	X	X	X	X	X			X	
	RECEIVE	X	X	X	X	X			X	
WMEC-270	SEND	X	X	X	X	X			X	
	RECEIVE	X	X	X	X	X			X	
WMEC-210	SEND		X	X					X	
	RECEIVE		X	X					X	
WLB	SEND			X					X	
	RECEIVE			X					X	

3. WMEC-270

WMEC-270s are the newest major class of Coast Guard cutter and have the most modern communications suite. They have satellite, HF, and UHF secure record message send and receive capabilities. Their assigned mission is the predominate factor in determining which system they utilize, and their flexibility and redundancy almost ensure their continual ability to receive secure or non-secure RATT. The main dilemma facing the WMEC-270's radio room is their lack of radiomen. They are only billeted for four radiomen, including the radioman-in-charge (RMIC). Consequently, a typical watch is extremely busy because of and in spite of their excellent capabilities, and intensifies if anything other than routine tasks are required. This will become more apparent during the discussions of tasks and duties in a shipboard radio room environment.

4. WHEC-378

WHEC-378s have good communications capabilities and redundancy. They are able to absorb some equipment failures without degrading their effectiveness. Because their satellite capabilities are limited to receive only, its uses differ between coasts. Atlantic area cutters on Coast Guard missions almost exclusively copy the Coast Guard HF broadcast, reserving their satellite receive capability for operation in U.S. or NATO naval exercises. However, the Pacific area WHEC-378's almost always copy the Navy Fleet

Satellite (FLTSAT) broadcast regardless of the mission because of its reliability, and the poor HF propagation in many parts of the Alaskan fisheries operating areas. All WHEC-378's are scheduled to receive the Naval Modular Automated Communications System (NAVMACS) satellite communications interface system during their midlife Fleet Renovation and Modernization (FRAM), so the entire class will have the option to send and/or receive messages through the Navy FLTSAT system.

5. WAGB

The Polar class icebreakers are presently the most communications capable ships in the Coast Guard. As shown in Table I they have HF ORESTES, satellite communications, and UHF line of sight secure record message capabilities. Additionally they have LF and VLF secure receive only capabilities. These excellent communications assets are tremendous as long as the icebreakers are not working in the Antarctic. There, because of the Antarctic Treaty of which the United States is a signatory, all stations and ships in the Antarctic region are open to inspection by personnel of any other nation. Consequently all secure and satellite capabilities are removed prior to deployment there, forcing the icebreakers to rely primarily on UNCLAS HF RATT for communications.

B. CUTTER RADIO ROOM TASKS, PERSONNEL, AND FUNCTIONS

1. Radio Room Tasks and Functions

Tasks and functions performed in radio rooms on Coast Guard cutters vary only with installed equipment and mission of the unit, but all have the same goal, to send and receive record message traffic as efficiently and easily as possible. A two person watch consists of a Watch Supervisor and a junior or less experienced radioman. While the Watch Supervisor is overall in charge and responsible for the proper running of the radio room during his watch, the duties of the watch are normally shared equally. A one person watch is responsible for everything. These duties include, but are not limited to the following:

(1) Maintain present communications and equipment status by shifting frequencies or making other changes when necessary ensuring reliable communications including any broadcasts copied. Watchstanders are also required to notify the ship's electronics technicians and other appropriate personnel of any equipment casualties.

(2) Guard the 500 kHz CW distress frequency and any other frequencies or nets required by the mission or command. Guard requirements for 500 kHz vary with the type of radio watch stood. It is only required to be guarded when a radioman is on watch, and it may be placed on a speaker for monitoring when the operator(s) are involved in other radio operations [Ref. 7:p. 16-2].

(3) If the ship is on a communications schedule the watchstander must receipt for all incoming messages. If copying a broadcast, he/she will monitor it and pull off all message for the ship. Requests for retransmission of any messages missed are also prepared and released.

(4) The radioman must ensure all messages are routed to the proper individuals on board. He/she also prepares all messages for transmission. This involves checking for proper addressees, proof reading the text, typing the message into the teletype, ensuring proper reviewing and releasing signatures, and routing of the message for final review. The message can then be sent.

(5) Maintain circuit discipline if on a local circuit.

(6) The duty radioman must set up transmitters and receivers for other areas of the ship as requested, such as the Combat Information Center or the bridge.

(7) The radioman must conduct compartment cleanups and perform minor preventative maintenance.

(8) The watchstander must maintain proper radio logs and perform other administrative duties such as classified material destruction and key card replacements.

(9) During law enforcement patrols setting up special phone or RATT patches and conducting intelligence checks on suspect vessels are common requirements.

2. Watchstanding Personnel

The number of radio room watchstanders differs between classes of cutter, and intensity and type of mission on which the ship is deployed on. All watchstanders are 'A' school graduates (either CG or other service equivalent). Some missions such as Naval exercises require more than the normal number of radiomen on watch and/or a change from the standard one in three rotation to a port and starboard schedule. At other times surges in the ship's communication requirements due to unanticipated operations require augmentation of the normal radio room watch. Relatively, this is not a problem onboard radioman rich units such as

WAGBs and WHECs, but severely taxes the communications personnel assets on WMECs and WLBs. Radiomen also are not just limited to eight hours of watchstanding onboard. They have housekeeping, maintenance, and administrative duties to perform and may also be involved in other time consuming activities such as law enforcement boarding parties. Another critical watchstanding factor is the experience level of the radiomen assigned. One ship may have all well qualified radioman capable of standing a one person watch, while another cutter may have to adjust its radio room watch schedule because of the number of new and inexperienced radiomen onboard.

a. WAGBs and WHECs

Icebreakers and WHEC-378s have sufficient radiomen to stand two man watches in a one in three rotation or a three man watch in a port and starboard schedule, and still have a day worker (normally an RM1) and the RMIC available. They can tend to the required administrative duties and be on call to augment the watch, troubleshoot, or provide technical assistance when communication difficulties arise. Radio gangs on these class ships are able to satisfactorily meet all watchstanding and non-watch requirements demanded of them.

b. WMECs and WLBs

WMEC-270s and 210s both are billeted for four radiomen. Predictably, they stand a one man watch in a one in three rotation with the RMIC as a dayworker and backup. However, that is not a critical factor on WMEC-210s because their capabilities are already limited by their lack of communications equipment. Even participation in Naval exercises does not change the mode of operations in the radio room except in numbers of messages received and sent. The number of guarded RATT circuits cannot increase.

The 270 class cutter is exactly the opposite. Because of their ability to copy four secure circuits simultaneously, they can quickly become overwhelmed in a high intensity Naval scenario. The normal one man watch is out of the question, and a two man watch on a port and starboard schedule leaves no one available to be called if problems arise.

Long range WLBs do not stand a continuous radio room watch. Their two radiomen keep an assigned schedule, normally 16 hours per day, with the Communications Station that is maintaining their guard. During their assigned schedule times they establish communications with the Communications Station to receive any traffic for the cutter and to send any outgoing messages. Urgent needs to established a RATT circuit are relayed by voice guarded on the bridge.

3. Watchstanding

A two man watch is able to perform all of the tasks previously listed and still maintain a fairly credible watch on 500 kHz and other guarded frequencies. However, a one man watch is hard pressed to perform the listed duties, even at a reduced level and still maintain a vigilant listening watch on the required circuits. The tempo of each watch is different. For example, some watches may be required to type and prepare many messages for transmission, while others will do none. Consequently the level of alertness in guarding required frequencies varies with each watch and watchstander. This type of "guarding" of the 500 kHz CW distress net technically meets the previously defined Commandant's requirements.

4. Task Performance

The amount of time required to perform the normal duties of a radio room watch varies from watch to watch. The distress guards and other required frequencies are always up and require listening to regardless of what else is being done. The time to perform the on watch duties listed in paragraph 2 is heavily dependent on the mission and current operations of the cutter, and can change virtually from minute to minute. Copying a continuous message broadcast that has numerous subscribers such as a satellite or the Coast Guard Atlantic Area HF broadcast requires constant attention from the on-watch radioman.

Watchstanders on units on a communications schedule or copying a less busy broadcast may have an easier time. Overall the pace of a radio room watch can be dead slow or so hectic that extra watchstanders must be requested. Normally it falls somewhere in between and is a function of mission, emission control status, number of watchstanders, time of day, and actual ship's operations at that instant.

C. COAST GUARD COMMUNICATIONS STATION

The capabilities and responsibilities of the nine Coast Guard radio/communication stations do not differ significantly. They perform a myriad of tasks in a much more settled, yet regimented atmosphere than on a cutter. There are typically ten generic operator positions in the communication operations center with a chief or first class radioman normally assigned as Communications Watch Officer(CWO) in charge. The positions manned at each station is a function of its size, capabilities, and current operations. The operator positions are:

- MF Distress(CW) 500 kHz
- Spare MF Distress
- HF CW
- SITOR or AMVER
- HF Secure RATT(1)
- HF Secure RATT(2)
- HF Secure Voice
- Tech Control
- HF UNCLAS RATT
- HF Clear voice
- Voice Broadcast
- Watch Supervisor

The operators report to the Watch Supervisor, while the CWO is overall responsible for the operations center. There are four duty sections in the watch rotation and each watch lasts 12 hours. Watchstanders rotate through the operator positions on an hourly basis and are collection of RM2's, RM3's, and SN/SARM's. Normally there is at least one junior radioman in training in each watch section.

The MF CW distress guard, HF CW circuit, and SITOR circuit operator positions are of primary concern in this thesis. Continuous headset watches are kept on the CW distress and HF circuits at a Communications Station, while the SITOR circuit is monitored on a model 40 teletype. The purpose of the CW distress frequency is self-explanatory. HF CW and SITOR perform the same function in different manners. Merchant vessels, commercial and government owned, send messages such as position reports, weather observations, requests for transitting Naval operation areas, fisheries, and Captain of the Port related topics over both circuits. The Communications Station then sends any needed reply back over the same circuit. The circuit used is mostly dependent on the ship's communications equipment and the radio operator. In the Pacific Area, the amount of use each circuit gets also seems to be a function of the location of the ship. As displayed in Table 3 [Ref. 8] Coast Guard Communications Stations Honolulu and Guam receive a much larger percentage of their merchant ship

traffic over SITOR than Communications Station San Francisco. This can be contributed to a variety of reasons, a major one being the type of merchant traffic they serve, coastal versus oceanic shipping.

TABLE 3

SITOR VERSUS HF CW TRAFFIC

	CW HF		SITOR	
	SENT	RCVD	SENT	RCVD
San Fran	2984	21,615	450	1038
Honolulu	6813	21,048	5991	3936
Guam	9843	17,804	8118	4241

Table 3 represents the number of merchant vessel messages sent and received from July through December 1986.

Chapter IV will discuss the potential benefits and disadvantages of replacing the HF CW and CW distress circuits with SITOR AND DSC.

IV. FUTURE COAST GUARD SITOR/DSC USES AND COST ANALYSIS

A. SITOR

The use of SITOR communications for record message traffic on Coast Guard Cutters has been tested on several occasions, but has never been operationally implemented. Chapter V of this thesis provides the basic plan for another test to be conducted by the 14th Coast Guard District late in FY-86. Results should help determine the reliability of using SITOR in a communications environment without active intervention by a radioman. Although SITOR communications with merchant vessels is the primary use of it by the Coast Guard, it accounts for only about 23 percent of the total merchant traffic through Coast Guard Communications Stations. The remainder is on MF and HF CW [Ref. 8].

1. Cutters 180 Feet and Less

Most Coast Guard Cutters 180 in feet length and less do not have radio rooms or radiomen on board. Their maximum time underway without returning to port is normally (with exceptions) a week or less. Cutters falling into this category are most buoy tenders, small icebreakers, and patrol boats. Receipt of record message traffic while underway is usually by voice, a long and sometimes frustrating process. Otherwise no traffic at all is received at sea.

Since SITOR is a proven record message communications method, the question is not if it will work on Coast Guard Cutters, but how dependable it is in a stand alone environment with minimal operator involvement. The operational test outlined in Chapter V is designed to help determine that.

2. Icebreakers

As stated in Chapter III, icebreakers operating in the Antarctic require the removal of all encryption systems before deploying there. Consequently during those trips they rely solely on UNCLAS HF communications, normally sending and receiving messages once or twice a day from the Coast Guard Communications Station that is maintaining their guard. Typically, propagation characteristics around Antarctica are poor making normal HF communications extremely difficult and sometimes impossible. A SITOR communications system could be installed temporarily on all icebreakers going south to augment their normal UNCLAS HF RATT capability. Because of the repetitive nature of the SITOR ARQ and FEC modes, more reliable communications may be realized.

Installation of SITOR equipment on icebreakers deploying to Antarctica would be a relatively easy task. Space and weight considerations would not be factors, and the installation could be temporary or permanent. Additionally, the load on Communications Stations might be

reduced due to fewer requests for retransmissions and the need to maintain a communications schedule could be eliminated. No decreased radiomen manning levels onboard the icebreakers would be realized due to the significant amount of scientific, operational and administrative traffic generated during long deployments.

Use of SITOR on cutters in the Great Lakes also offers potential. CGC MACKINAW, five 140 foot icebreaking tugs, and five WLB-180s are stationed throughout the lakes and rely on voice or a VHF-FM American Standard Code for Information Interchange (ASCII) system for sending and receiving record message traffic. SITOR would permit use of HF rather than VHF for communications.

3. Merchant Vessel Communications

By far, the best chance for saving money with SITOR is by increasing its use by merchant vessels, replacing HF CW that could ultimately lead to the elimination of the HF CW positions at Communications Stations. As calculated from Table 3, 87 percent of merchant vessel messages to the Pacific Area Communications Stations listed in the table are on HF CW. Phasing out the use of CW circuits in favor of SITOR or satellite communications would eliminate one watchstander position, or four and one-half full time equivalent (FTE) employees [Ref. 9:pp. 28-A-1,2]. Assuming

those eliminated would all be E-4 billets, the below savings per billet would be realized:

	In conus	Outside conus
- Personnel Salary Costs:	$18,400	$18,400
- Personnel Support Costs:	3,967	6,115
Total Savings:	$22,367	$24,515

Therefore, annual personnel savings in FY-86 dollars at a Coast Guard Communications Station with one HF CW position would be 5 X $22,367 or $111,835.[Ref. 10] Although the number of FTEs eliminated is really four and one half, the Coast Guard's standard policy is that all fractions of people will be rounded up [Ref. 10]. Actually, the deleted radiomen would be a combination of E-4, 5, and 6 billets, providing even higher dollar savings. The deleted CW position would have to be replaced with another SITOR system at a cost of about $20,000. Thus, overall first year savings due to elimination of personnel would be approximately $90,000 minus maintenance and support costs. The second SITOR position could be manned by the regular SITOR watchstander without overburdening him or her. Because of the deletion of HF CW SITOR traffic would undoubtedly increase. 50,000 merchant vessel messages received on SITOR per year at each Communications Station averages out to about 6 messages per hour. As a comparison, Communications Station Guam had the highest percentage of SITOR messages received in Table 3, yet averaged only about

one per hour over the six month period. Interviews with Communications Station personnel indicate that six messages per hour could be processed easily by one person.

4. Other Cutters with Manned Radio Rooms

Installation of SITOR on WHEC-378s and WMEC-270s would not contribute much to their overall communications capabilities. The post-FRAM WHEC-378s and all WMEC-270s both have satellite and HF transmit and receive capabilities, so SITOR would serve as a last resort backup system. Although SITOR should be more dependable in poor HF propagation conditions than 100 words-per-minute (wpm) RATT, it is at least 33 percent slower [Ref. 6:p. 4-30], and from the author's experience, even its improved quality does not [illegible] FLTSAT broadcast. Because of [illegible]

[illegible] have sufficient radiomen, and neither would benefit by trading radiomen for SITOR. Additionally, from the author's observations, there are too many other requirements such as shipboard maintenance, administrative duties, and inport watchstanding required of the radiomen for these cutters to lose any.

WMEC-210s would definitely benefit from the addition of SITOR to their communications suite, since their limited capabilities are extremely vulnerable to casualties to their primary HF system. Despite SITOR's UNCLAS mode, it

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WMEC-210s would definitely benefit from the addition of SITOR to their communications suite, since their limited capabilities are extremely vulnerable to casualties to their primary HF system. Despite SITOR's UNCLAS mode, it

would be an excellent backup system or could be used in tandem with their normal HF circuit. SITOR could be used for all unclassified administrative type traffic, while the HF ORESTES circuit is used for For Official Use Only (FOUO) and messages of higher classifications. This would be especially useful during Naval or readiness exercises where classified exercise traffic can rapidly overload the WMEC-210's single covered circuit. Addition of SITOR would not take the place of any radiomen.

Of the four cases presented, the one that demonstrates the best likelihood for saving costs is the expanded use of the present SITOR system within the merchant fleet. The second best opportunity for SITOR is on units without manned radio rooms and limited secure needs. This includes icebreakers deploying to the Antarctic, those without radio rooms, and cutters on the Great Lakes. Finally, SITOR could be used as a backup on cutters with manned radio rooms.

B. DIGITAL SELECTIVE CALLING (DSC)

Presently, the International Maritime Organization (IMO) has scheduled DSC for a phase-in period beginning in 1991 and continuing through 1997 [Ref. 11]. The schedule is as follows:

- 1 Aug 1991 - all new ships over 1600 gross tons must have VHF, MF, and UHF DSC.
- 1 Feb 1994 - all ships over 1600 tons built after 1985
- 1 Feb 1997 - all remaining ships over 1600 tons

The DSC distress call as described in chapter II, will be transmitted on the following frequencies:

- 2187.5 kHz
- 4188.0 kHz
- 6282.0 kHz
- 8375.0 kHz
- 12563.0 kHz
- 16750.0 kHz [Ref. 12]

The monitoring of these frequencies by automated DSC equipment will eliminated the need for live 500 kHz and 2182 kHz watchstanders. This then allows for the elimination of four and one-half FTEs per position. First year personnel costs savings, per position, in FY-86 dollars parallels that of SITOR, and would more than recover initial equipment procurement and installation costs. Estimates for procuring the HF DSC systems for use in Communications Stations are $43,000 each [Ref. 13] and installation and training expenses are about $8,000 [Ref. 14] for a total of $51,000. Subtracted from the yearly personnel savings of $111,835, over $60,000 in annual savings could be realized by shifting to automated DSC guarding of distress frequencies. A minimum of 9 systems, one for each communications station, will be needed by 1991, with more as the number of ships with DSC equipment increases through 1997. Maintenance and support costs for the DSC systems should not be any higher than for that of the systems it replaces.

None of these savings will be fully realized until 1997, when IMO's Digital Selective Calling requirements for

all large ships takes effect. Until then both distress systems will have to be guarded at Communications Stations. However because of its automatic alarm feature, DSC should not require any additional personnel.

1. Shipboard DSC Distress Systems

Government and Military ships are exempt from the IMO DSC distress and calling requirements in accordance with the Communications Act of 1934 (amended) and the Safety of Life at Sea Conferences [Ref. 15]. However, the very nature of the Coast Guard's missions dictate an obligation to employ the system on its cutters.

2. DSC/SITOR Implementation

Introduction of total SITOR or alternative communications vice CW in the merchant fleet and DSC distress and call guarding at Coast Guard communications stations, and elimination of their corresponding older systems could ultimately save a total of 13 positions and 52 people at Coast Guard Communications Stations.[Ref. 16:p. III-8] Using an in conus, E-4 base, and assuming the billets are deleted not reprogrammed, yearly personnel savings, in FY-86 funds, would be $1,163,084. As with any new system there are also costs associated with starting up and running it. They include:

- Initial equipment and installation charges
- Any facility modification costs

- Reoccurring operating costs
- Maintenance and support costs [Ref. 16:p. A-12,13]

The decision to eliminate one system for another must take into consideration the above costs as well as potential savings from other areas such as maintenance, energy, and spare parts. In the case of expanding the use of SITOR by eliminating HF CW, savings accrued by replacing one system by another must exceed the life cycle costs of the new one. If not, one must question the basic premise on which the decisions to replace the original system were based.

Because DSC use will be mandated, there is no conscious cost saving decision to be made prior to the initial purchase. However, after the phase-in period, the previous figures indicate that personnel savings from eliminating the live watchstanders should be substantial, and might eventually exceed the costs of installing and operating the DSC system.

V. PROPOSED DIGITAL SELECTIVE CALLING/SITOR TEST PLAN

Operational tests for any new system or process involve many different aspects. Decisions involving the type of equipment to be used, test platform(s), pre-test training, impacts on normal operations and added requirements on involved personnel must be determined prior to starting the experiment.

A. TEST UNITS

This plan is being developed for and with the Fourteenth Coast Guard District (CCGD14) in Honolulu, HI. It will involve Coast Guard Communications Station Honolulu and a WLB-180, either CGC MALLOW or CGC SASSAFRAS. Determination of the test platform will be made by CCGD14 staff elements taking into consideration operational requirements, availability for equipment installation, and time available for training.

1. CCGD14 Role

The Fourteenth District staff elements primarily involved in the DSC/SITOR tests are the Telecommunications Division(dt) and Electronics Engineering Branch(eee). The eee branch is responsible for determining desired equipment, purchasing it plus spare parts, initial shoreside testing, and installation and testing of the gear on the WLB. Once

the testing is complete on the cutter, eee's primary role is over. During the tests they will be used as a technical advisor. The dt division is responsible for reviewing and implementing this operational test plan, coordinating training with the units involved, and analyzing the data collected. Dt's evaluation of the tests will then be forwarded to Commandant(G-TES-1) Coast Guard.

2. WLB-180 Role

The long range WLB's in the 14th Coast Guard District create a unique set of circumstances. They routinely travel hundreds and thousands of miles from their homeport performing their Aids to Navigation mission. With only two radiomen onboard they are unable to keep a 24 hour watch in the radio room. Consequently they can receive messages only two-thirds of the time they are underway. Although it is rare that they have an immediate need to receive message traffic during their eight unmanned hours a day, the capability would beneficial.

The WLB selected to participate in the test will be the key to the entire experiment. The cutter will receive numerous test and actual messages in the different SITOR modes, and will randomly receive and transmit simulated distress or alerting calls on DSC. Additionally the radiomen will be standing their normal radio schedule to receive and send record message traffic in their usual manner. Bridge watchstanders will have to be alert for the

DSC distress alarm in order to make note of the time of receipt and to record the ship's position and employment. Addition of the DSC/SITOR equipment will require the removal of one URT-23 HF transmitter and associated gear. Data capture forms will be provided and will have to be filled out by involved personnel.

Impact on the WLB will not be too great, but will require some extra effort from the radiomen, bridge watchstanders and other selected individuals. Normal record message traffic will be received twice, once via SITOR mode and once via normal communications schedule. This is necessary to determine if messages are being received faster and just as reliably with the SITOR system as with the present system. During the DSC tests bridge watchstanders will have to respond to the DSC alarm , make appropriate entries on the data forms and send a DSC call back. Electronics maintenance hopefully will be reduced by replacing the URT-23 with a more state of the art piece of communications equipment.

3. Communications Station Role

Communications Station Honolulu will be required to initiate and keep records of all test and actual messages sent and received on SITOR and DSC in accordance with section D of this chapter. Additionally, the Communications Station will have to keep its regular schedule with the buoy tender to send and receive traffic in the normal manner.

Personnel should not be greatly impacted. The SITOR/CW broadcast position is normally manned, and even if it is not, it must still be manned on a regular basis to transmit scheduled CW and SITOR broadcasts. Transmitting a short test or actual message hourly should not overburden the SITOR/CW broadcast watchstander. The DSC distress test will be conducted four to six times per twelve hour watch, as directed by the Communications Watch Officer (CWO). Operators will be required to keep data sheets concerning the messages sent over SITOR and DSC to the WLB.

One potential problem at Communications Station Honolulu is the lack of available transmitters on which to conduct the tests. If problems in meeting the requirements of this test plan are identified, they will have to be solved jointly by CCGD14(dt) and Communications Station Honolulu.

B. TEST OBJECTIVES

There are two main objectives of this test. The first is to determine the dependability and reliability of sending SITOR ARQ and FEC messages to a WLB with an unmanned radio room, and the second is to test the DSC distress and calling system. Additionally the equipment installed on the WLB and Communications Station should be evaluated for shipboard compatibility, reliability, and user friendliness. This includes the Com-5300kw system, the Cubic R-3030 scanner,

the Harris 3500DX ARQ/FEC modem with DSC, and the Harris 5500 receiver and scanner. As an aside, the effective SITOR broadcast and DSC coverage areas, and the accuracy and dependability of Prophet predictions can be examined.

1. SITOR ARQ/FEC Mode Tests

Paragraph D.1 details the test procedures, but in general the SITOR tests will be conducted hourly to coincide with already scheduled broadcasts. Both test and actual messages will be sent to the WLB on SITOR. Actual message traffic will also be sent during their regularly scheduled communications schedules so the time difference between SITOR and communications schedule delivered traffic can be determined. Quality of the messages received is also important. If the SITOR message takes longer to get, but has fewer character errors and can be received in an unmanned mode, it may be that SITOR should be the primary mode of HF record message traffic communications on a WLB. Additionally, results may suggest a re-examination of the need for two radioman billets.

2. DSC Distress/Calling Test

Guidelines for testing MF/HF DSC calls are outlined in CCIR report 501-3 of Nov 1983. The tests are designed for the participating units to use typical transmit power with appropriate frequencies. Transmissions are to be done randomly to simulate distress calls and data collected should be call time, unit position, and if that call was

received by anyone [Ref. 1:p. 3]. Data collected can be submitted to CCIR study group eight via Commandant(G-TPP-3). The DSC test will be conducted both ways between the WLB, and the Communications Station. Results of the test should provide valuable data in determining the capabilities of DSC in calling or alerting shore stations and ships at sea.

C. TEST PARAMETERS

Prior to detailing the procedures of the test, the equipment must be described, and the factors and measures involved must be discussed and clarified.

1. Equipment

This test involves two different systems, a SITOR communications system, and a DSC calling/alerting system.

a. DSC System

The DSC distress and calling system to be used is composed of four parts, two each at the WLB and Communications Station. The WLB and Communications Station systems are identical with the exception of the transmitters. Figure 3 represents the components of the DSC receive system. It consists of the Cubic R-3030 scanner, Harris 3500DX ARQ/FEC terminal with DSC option and a Model 40 teletype with receive only capabilities.

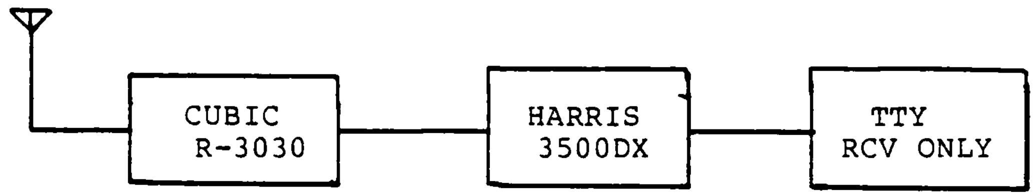

Figure 3. DSC Receive System - Communications Station/WLB

Both Communications Station Honolulu and the WLB will have DSC transmit capability. Honolulu will use the same equipment as the SITOR test, while the WLB will utilize its remaining URT-23 transmitter.

b. SITOR System

The system to be installed on the WLB is the Com-5300kw communications suite. It has RATT, voice, CW and SITOR capabilities, but for this test, only the SITOR option will be utilized. The Com-5300kw consists of the following components: Com-3648 HF transceiver, Com-1000B solid state amplifier, Com-5385 modem, PS-248 power supply, communications terminal, dot matrix serial line printer, and Com-1005 automatic antenna coupler. All of the components are contained in a 30 inch high by 21 inches wide by 23 inch deep cabinet [Ref. 6:p. 3-2]. The system is displayed in Figure 4. The Com-3648 transceiver in concert with the Com-1000B amplifier can transmit and receive signals between 1.6 and 30 mHz. It can scan up to 15 frequencies, remaining on each for about two seconds before shifting.[Ref. 6:p. 4-16] The Communications Station part of the SITOR test system is

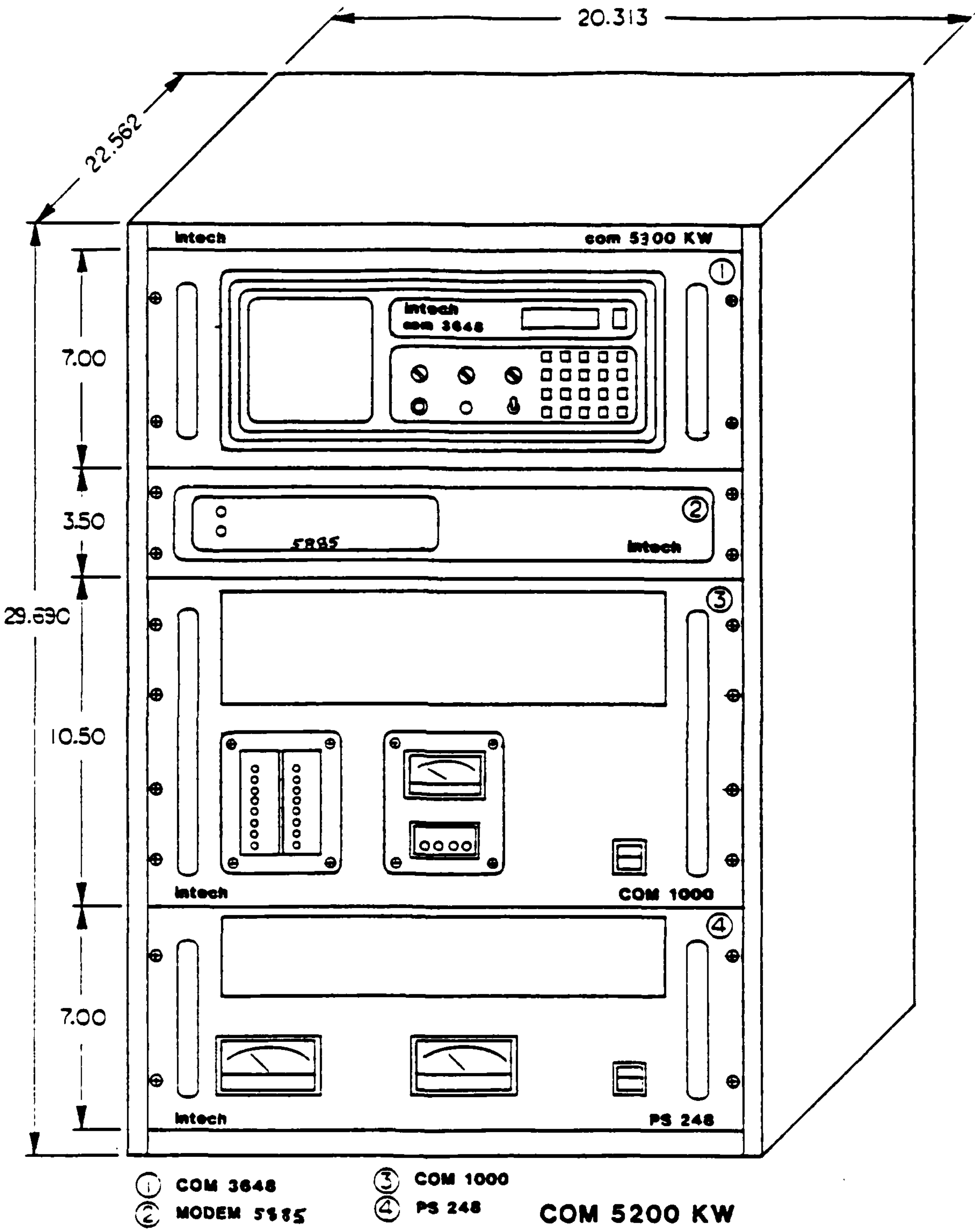

Figure 4. Com-5300kw System

already installed and used daily for sending and receiving SITOR traffic from merchant ships. It has four separate components, Harris 550 receiver with scanner, Harris 3500DX, model 40 receive/send capable teletype, and U.S. Navy FRT-39 transmitters. This system is displayed in Figure 5.

The Communications Station system will be used to send all DSC test calls and all test SITOR messages. Additionally it is used to send all SITOR broadcasts and communicate with other SITOR capable units.

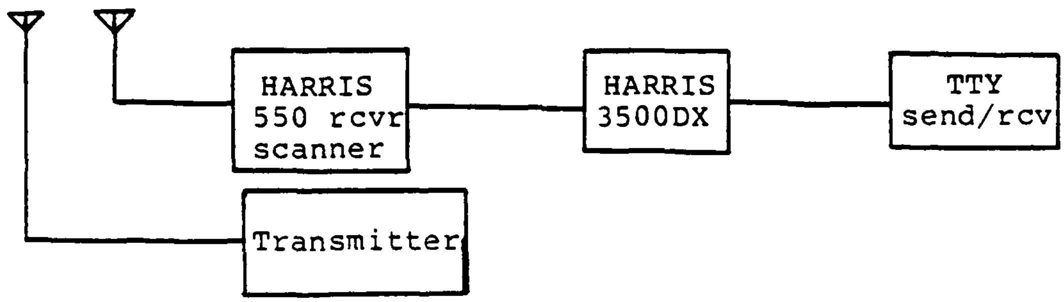

Figure 5. DSC/SITOR Transmit System - WLB/Communications Station

2. Test Factors

A factor is something that effects the test or experiment. Factors can be controlled and are used to influence the measures of the test. These tests have two primary factors, frequency and mode of communications, ARQ, FEC, or regular RATT broadcast. Frequency selection is critical to HF communications, and is affected by two secondary factors: WLB position or distance from the Communications Station, and time of day(night, day, or dusk).

Each of these primary factors can be controlled or changed at any time except the buoy tender's position. However, that is not too significant because the frequencies used can be adjusted to compensate for it. Messages will be sent on all three modes of communications during all times of the day, so the effect on each mode can be determined.

3. SITOR Test Measures

For the SITOR communication tests the measures will be the missed or incorrect character rate, and the time to receive actual messages on SITOR as compared with receiving them on the normal communications schedule.

a. Incorrect Character Rate

The incorrect character rate is defined as the percentage of character errors per message. For test purposes, this will include all characters between the break transmissions (BTs) on test and actual messages, and the entire body of the message for SITOR broadcasts. For example, if there are 200 characters in a message and 7 are in error, the character error rate is 3.5 percent. This percentage can be plotted in terms of time and frequency. Figure 6 illustrates a plot of two frequencies and their associated character error rate over a 24 hour clock. The reader should note that this figure is not based on empirical data but is for illustration purposes only.

This graph will provide the user with a method for predicting character error rate, given time of

day (TOD) and frequency. By forming a linear regression with the data gathered for each frequency, the probability of a any character error rate can be calculated. It can be stated in the following formula:

$$P(\%error) = a_0 + a_1(frequency) + a_2(TOD)$$

Detailed statistical analysis might indicate a better predictive capability if non linear regression or one linear in the logarithms is used. This could be useful in the future for determining the best times to send SITOR equipped cutters message traffic.

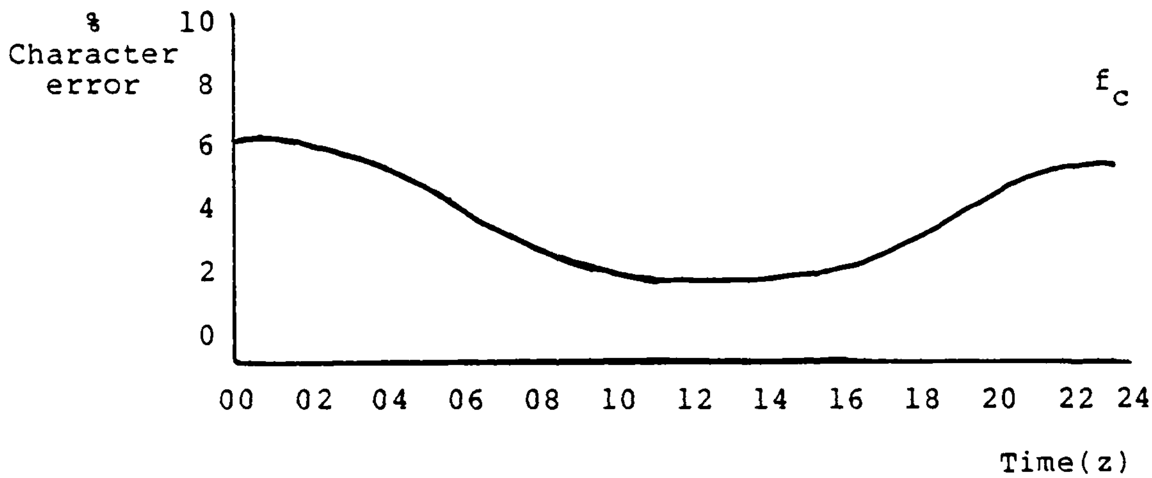

Figure 6. Percent Character Error Versus Time of Day for Selected Frequencies

b. Difference in Message Receipt Time

The second measure is the time difference between receipt of a message on SITOR and the normal broadcast. It will be used to determine the probability of

receiving a message faster on SITOR than on the current communications schedule system. This measure will only be calculated for actual messages received on the two systems, not test messages or SITOR broadcasts. Although sending messages twice requires extra effort on both the Communications Station's and WLB's part, it is a necessary segment of the test to prove SITOR can be as or more reliable than the existing system. Given the nature of a communications schedule, there will be some instances where SITOR is at least four hours faster, such as when a message for the WLB is received at a Communications Station just after the schedule has terminated. At other times there will not be any discernible difference. Figure 7 displays a histogram that might represent results of this measure.

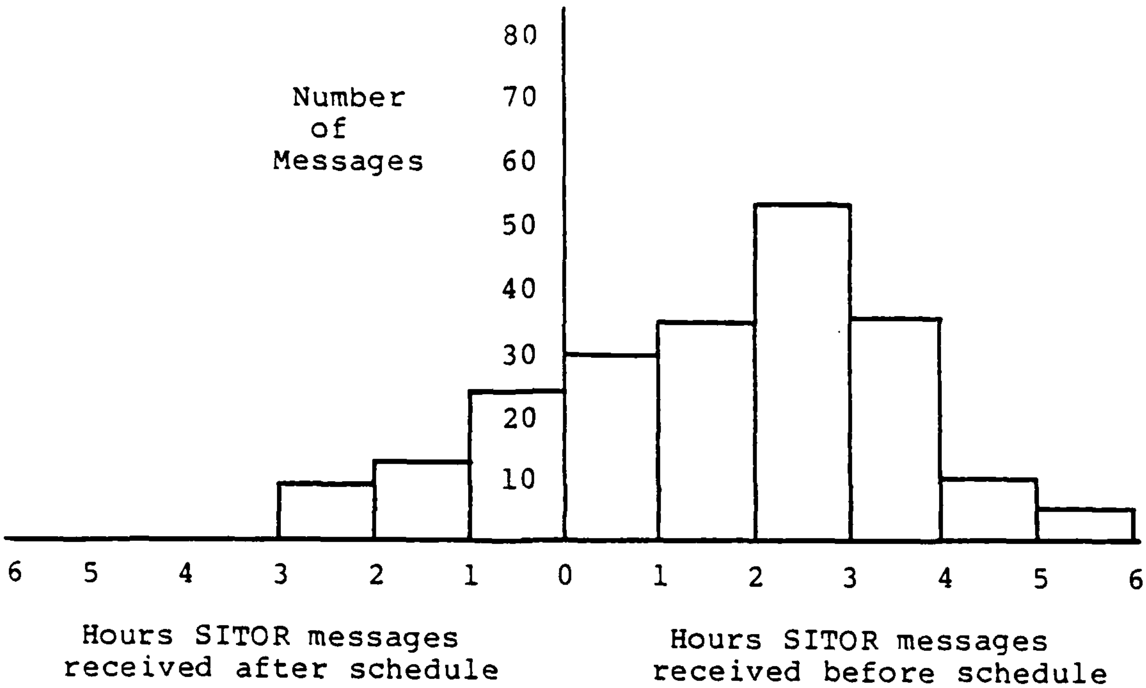

Figure 7. Number of SITOR messages versus Time Received Before/After Schedule messages

Ideally, all messages plotted should have a constant character error rate. However, for test purposes, all SITOR messages received, and the corresponding normal schedule messages, at the time deemed acceptable for receipt, as determined by the radioman on watch using his normal criteria, will be used. If results should appear unrealistic, a constant character error rate should be chosen and the time differences replotted. Once all message time differences have been obtained or calculated the type of probability distribution that bests fits this empirical description can be obtained via regression techniques. For the "fitted" regression the standard deviation(variances)

and the probability of at least a given difference can be obtained.

c. Subjective Measures

Although less objective, consideration must be given to the people who operate and utilize the new system. Comments concerning user friendliness, complexity, maintenance, use by non-technical personnel, and other areas are extremely important. A system may have a very good statistical record, but if it is too complicated for a third class quartermaster to operate, it will not be useful to the ship. A User Evaluation Form, should be developed and filled out by all personnel involved with the SITOR or DSC systems. Additionally, the cutter's Commanding Officer's comments are critical, as he has the experience to see how the system impacts on the total operation of the ship.

4. DSC Test Measures

The DSC test measures are the percent of calls received and character error rate.

a. Receipt of Distress Calls

This measure is cut and dry, either the DSC call was received, or it was not. The percent of DSC calls received can be plotted versus time of day and frequency. Figure 8 illustrates the percent of calls received as a function of time of day for a fixed frequency. As before it

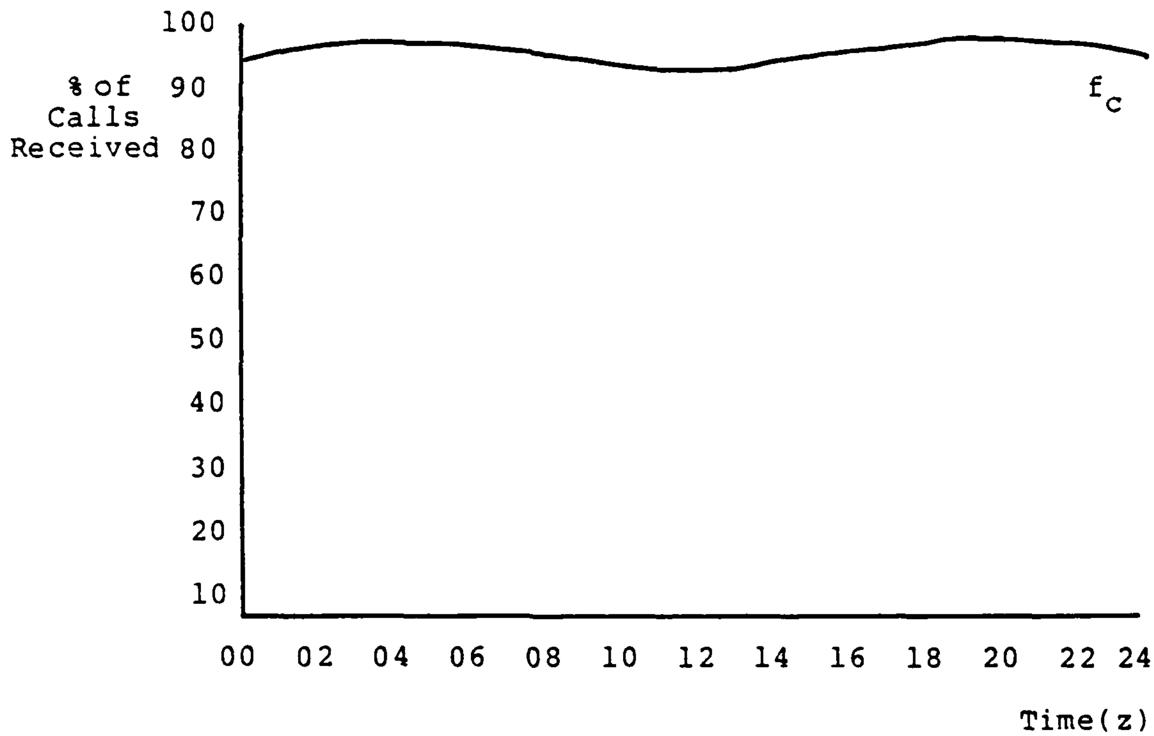

Figure 8. DSC Calls Received versus TOD for a Selected Frequency

is for illustrative purposes only and is not based on empirical fact. The analysis of this measure is identical to that of character error rate in the SITOR test. Again, by using linear regression, the probability of receiving a call made on DSC can be expressed as a function of a constant, time of day, and frequency. It is expressed in the following formula:

$$P(\text{receiving call}) = b_0 + b_1(\text{TOD}) + b_2(\text{frequency})$$

Results from the DSC test will also help to determine area coverage for the system once implemented.

D. TEST PROCEDURES

This section has two parts, the SITOR communications test and the DSC distress and alerting test. The tests as described below should be conducted during the times Communications Station Honolulu has the communications guard for the participating buoy tender.

1. SITOR Communications Test

a. SITOR test times

SITOR test messages will be sent in conjunction with Communications Station Honolulu's CW broadcast schedule and during the gaps between the CW and SITOR broadcasts. A short SITOR test message will be sent to the WLB during the following CW broadcasts:

- 0100Z
- 0300Z
- 0600Z
- 1300Z
- 1700Z
- 2000Z
- 2200Z

Additionally the WLB will copy the regularly scheduled SITOR weather, hydropac, and navarea broadcasts at these times:

- 0130Z
- 0330Z
- 0430Z
- 0630Z
- 0730Z
- 1330Z
- 1730Z
- 2030Z
- 2230Z

To fill in the gaps between the CW test messages and SITOR schedule, a test or actual message will also be sent at the following times:

- 0830Z
- 0930Z
- 1030Z
- 1130Z
- 1430Z
- 1600Z
- 1900Z
- 2359Z

A total of twenty-four messages/broadcasts will be sent daily for the WLB to copy. All actual record message traffic for the ship will also be sent on SITOR. Actual messages will supercede the next scheduled test message. All SITOR broadcasts will be copied by the WLB since they will be broadcast regardless. The overall daily test sequence and mode to be utilized is as follows:

- 0100Z - test msg(ARQ) to coincide with CW bcst
- 0130Z - SITOR bcst
- 0300Z - test msg(ARQ) to coincide with CW bcst
- 0330Z - SITOR bcst
- 0430Z - " "
- 0600Z - test msg(ARQ) to coincide with CW bcst
- 0630Z - SITOR bcst
- 0730Z - " "
- 0830Z - test msg(ARQ) to coincide with CW bcst
- 0930Z - test msg(FEC selective)
- 1030Z - test msg(ARQ)
- 1130Z - test msg(FEC selective)
- 1300Z - test msg(ARQ) to coincide with CW bcst
- 1330Z - SITOR bcst
- 1430Z - test msg(ARQ)
- 1600Z - test msg(FEC selective)
- 1700Z - test msg(ARQ) to coincide with CW bcst
- 1730Z - SITOR bcst
- 1900Z - test msg(ARQ)
- 2000Z - test msg(FEC selective) to coincides with CW bcst
- 2030Z - SITOR bcst
- 2200Z - test msg(ARQ) to coincide with CW bcst
- 2230Z - SITOR bcst
- 2359Z - test msg(ARQ)

The test times cover the entire 24 hour clock ensuring transmission during all hours of the day and all propagation conditions for the test period. Of the 24 messages to be sent daily, only eight test message transmission times do not correspond with a CW or SITOR bcst.

b. General Test Procedures

The normally scheduled SITOR broadcasts will be copied by the WLB on one of the published Communications Station Honolulu SITOR frequencies, 8714 kHz, 13082.5 kHz, and 22572.5 kHz. Test messages and record message traffic for the WLB should be transmitted on one of the following calling duplex frequencies were designated by the Commandant (G-TES-1):

Ship Transmit	Coast Transmit
4187.5 kHz	4357.0 kHz
6281.5 kHz	6506.0 kHz
8375.5 kHz	8718.5 kHz
12562.0 kHz	13100.5 kHz
12562.5 kHz	13100.5 kHz
16750.5 kHz	16751.5 kHz
22248.0 kHz	22595.0 kHz
22248.5 kHz	22595.5 kHz

The frequency chosen for transmission will be based on the Prophet predictions for the time, date, and geographic position of the cutter.

c. Test Message and Data Capture Forms

The test message, as displayed in Figure 9, will be in standard Coast Guard message format preceded by the test unit's Selcall number and any other peripherals

required by SITOR. Selcall numbers were assigned to 14th District WLBs prior to a previous test. They are:

- CGC MALLOW - 10501
- CGC SASSAFRAS - 10502
- CGC BASSWOOD - 10500 [REF. 17]

```
R 010001Z AUG 86
FM COGARD COMMUNICATIONS STATION HONOLULU HI
TO USCGC__________
ACCT CG-________
BT
UNCLAS //N      //
SUBJ:  SITOR TEST (ARQ or FEC depending on test time)
1.  THIS IS A TEST MESSAGE.  PLEASE FILE AFTER
RECORDING THE DTG AND THE NUMBER OF MISSING OR
CHARACTER ERRORS ON DATA CAPTURE SHEET 2.
2.  THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG'S
BACK.
BT
```

Figure 9. SITOR Test Message

The only change the Communications Station watchstander need make in each message is the date time group, which should be the same as the scheduled test time. This will make correlating data after the test somewhat easier.

Data will be compiled at the Communications Station and the cutter and recorded on the forms in the Appendix. Form 1, as displayed below will be utilized at the Communications Station. It has six columns, scheduled test time, message DTG, message type, SITOR mode, transmission frequency, and time of delivery (TOD). Each applicable column should be filled in with every message sent. At the top of each form the date and the time of sunrise and sunset

in Greenwich Mean Time (GMT or Z) in Honolulu should be recorded. Figure 10 is an example of how the form should be kept.

DATA SHEET 1 FOR SITOR TEST - COMMUNICATIONS STATION

DATE - 09 AUG 86 SUNRISE/SUNSET - 1525Z/100201Z

SCHEDULED TEST TIME	MSG DTG	MSG TYPE	MODE	TRANSMIT FREQUENCY	TOD
0100Z	090100Z	TEST	ARQ	6506.0kHz	0105Z
0130Z		SITOR BCST	FEC(C)	SITOR	0130Z
0300Z	081425Z	ACTUAL	ARQ	8718.5kHz	0245Z
0330Z		SITOR BCST	FEC(C)	SITOR	0330Z
0430Z		" "	"	"	0430Z
0600Z	NONE SENT				

Figure 10. SITOR Test Data Sheet - Communications Station

Data sheet 2 is for use on the WLB. It has six columns, scheduled test time, message DTG, message type, time of receipt(TOR) in GMT, number of character errors, and ship's position. Data sheet 2 will also have the date and GMT time of sunrise and sunset for that day for the cutter. Because there will be a radioman on watch 16 hours a day in the WLB's radio room, many of the messages received on SITOR can be logged in immediately. Those that are received during non-communication schedule hours may have to be logged in with an estimated TOR. Upon completion of the test those messages can be compared to the ones transmitted

by the Communications Station for that scheduled test period.

Figure 11 is an example of Data Sheet 2. Messages not sent or received for a scheduled test time should be noted along with the reason if known.

DATA SHEET 2 FOR SITOR TEST - WLB

DATE - 09 AUG 86 SUNRISE/SUNSET - 1622Z/100203Z

SCHEDULED TEST TIME	MSG DTG	MSG TYPE	TIME OF RECEIPT	NR CHAR/ ERRORS	SHIP'S POSITION
0100Z	090100Z	test/actual	090110Z	200/4	29-41N 125-00W
0130Z		SITOR bcst	090135Z	600/14	29-38N 124-56W
0300Z	081425Z	test/actual	090247Z	250/6	29-34N 124-50W
0330Z		SITOR bcst	090336Z	575/0	29-30N 124-46W
0430Z		SITOR bcst	090436Z	700/11	29-27N 124-41W
0600Z	NONE RCVD				29-24N 124-37W

Figure 11. SITOR Test Data Sheet - WLB

The number of characters in each message must also be determined. That calculation could be quite laborious, especially for the SITOR broadcast and actual message traffic, but is necessary to compute character error rate. Since test messages are all the same the character count will be predetermined and consistent.

d. Equipment Set-up

(1) Communications Station Honolulu. The equipment for the tests is basically in place at Communications Station Honolulu. Three Navy transmitters and three Harris 3500DX modems are presently dedicated to the SITOR broadcast. The transmitters cannot be easily retuned to accommodate SITOR test or actual message transmissions on the allotted coast transmit frequencies. However, Communications Station Honolulu may be able to utilize one of its fast tuning HF-80 transmitters for the small amount of time necessary to transmit a message on the frequency predicted by the Prophet program. If that is not possible, then the test will probably have to be conducted entirely on the dedicated SITOR frequencies.

A Cubic R-3030 dual scanner has been in place at Communications Station Honolulu for testing and evaluation since March 1986 and a Harris 550 receiver and scanner is presently being used with the SITOR system.

(2) WLB-180. As stated before, the equipment to be utilized on the WLB is INTECH Corporation's Com-5300kw communications system. This plan will not attempt to provided the directions for detailed operator training or equipment setup. The operator's manual is very adequate and detailed personnel training should be provided by INTECH through CCGD14. The proper settings for squelch, automatic gain control, and other signal enhancing controls will not

be addressed as these items are better decided on after the system has been received and is operating in a controlled environment. Once optimal settings have been determined, they need to be recorded. Any changes made to any setting must also be recorded, as they could effect the validity of the test. During the shoreside and dockside testing periods operators and technicians need the opportunity to experiment with the system for familiarization and find out how it works best. It is also very probable that adjustments will have to be made once the test platform is underway.

The Com-5300kw is capable of scanning fifteen different frequencies. Receive frequencies and corresponding transmit frequencies are programmed into the Com-3648 transceiver. The scanner remains on each programmed receive frequency for approximately two seconds. When the unit's selcall number or an all ships call is detected on one of the frequencies, the system stops scanning and links up with the calling station if it is an ARQ call, or locks on that frequency if in FEC mode. Upon completion of the link the system shifts back to scanning mode [Ref. 6:p. 4-26]. It is recommended that only the following frequencies be programmed into the Com-5300kw system:

RECEIVE	TRANSMIT
4357.0 kHz	4187.5 kHz
6506.0 kHz	6281.5 kHz
8716.0 kHz	8355.0 kHz
13082.5 kHz	12502.5 kHz
17232.0 kHz	16750.5 kHz
22572.5 kHz	22203.5 kHz

By scanning only six frequencies, the longest is should take the ship to pick up a signal is 10-12 seconds. The frequencies chosen are the three SITOR frequencies keyed by Communications Station Honolulu and three calling duplex frequencies to fill in the gaps. The SITOR broadcast is transmitted on three channels simultaneously to ensure adequate coverage. Test and actual messages should be sent out on the frequency(ies) determined to be best by Prophet predictions. The unit's selcall number should always be used on test and actual message SITOR transmissions.

Although it would be ideal to have all test messages sent as scheduled throughout the entire testing period, it is realized that operational requirements, equipment casualties, and other unforeseen circumstances will most likely prohibit that. However, if only 80 percent of the test and SITOR messages are transmitted and received for 42 days, over 800 data points will be established, more than enough to provide a meaningful analysis.

2. DSC Test Procedures

a. General Test Procedures

DSC tests will be conducted from shore-ship and ship-shore. Communications Station Honolulu will randomly transmit 4-6 DSC calling/alert messages per 12 hour watch in the frequency range predicted by Prophet for that date and time. Test times are at the option of the CWO, but must be random. Upon receipt of the DSC message, the WLB will respond with one of its own. Transmit frequencies will be chosen from the planned DSC distress and calling frequencies. They are:

- 2187.5 kHz
- 4188.0 kHz
- 6282.0 kHz
- 8375.0 kHz
- 12563.0 kHz
- 16750.0 kHz

Upon detection of a DSC call alarm on the WLB, the bridge watch will record the time of receipt in GMT, the ship's position, employment (i.e. underway, tending buoys, anchored, etc) and the receive frequency on the DSC data sheet. Figure 12 is an example of Data Sheet 1 as filled out by a WLB. A blank form is contained in the Appendix.

DATA SHEET 1 FOR DSC TEST - WLB

DATE/TIME	SHIP'S POSITION	EMPLOYMENT	FREQUENCY	#CHAR/ ERRORS
091522Z	25-33N/130-00W	U/W	2187.5	111/2
100321Z	24-55N/129-46W	U/W	2187.5	111/0
100744Z	24-41N/129-23W	BUOY OPS	2187.5	111/6
101233Z	24-40N/129-21W	ANCHORED	6282.0	111/3

Figure 12. DSC Test Data Sheet 1 - Communications Station/WLB

The WLB will then transmit a DSC message back to the the Communications Station which will also fill out Data Sheet 1 except for position and employment. Both test units will fill out Data Sheet 2, displayed in Figure 13.

DATA SHEET 2 FOR DSC TEST - COMMUNICATIONS STATION/WLB

DATE/TIME TRANSMITTED	FREQUENCY	# CHARACTERS
091522Z	2187.5 kHz	111
101321Z	2187.5 kHz	111
100744Z	2187.5 kHz	111
101237Z	6282.0 kHz	111

Figure 13. DSC Test Data Sheet 2 - Communications Station/WLB

The DSC test message should be in accordance with CCIR Recommendation 501-3(draft) and be can be in the distress or calling format. Figure 14 displays a printout of the DSC distress call.

MESSAGE RECEIVED   00-AUG-00   00:16:43

DISTRESS CALL
BBBB

DISABLED AND ADRIFT

SE QUADRANT
LONGITUDE 012 DEGREES 12 MINUTES
LATITUDE 12 DEGREES 12 MINUTES

RYRYRY

Figure 14. DSC Distress Message Model

b. Equipment Set-up

The Harris 3500DX modems at Communications Station Honolulu have the DSC option as does the one scheduled to be installed on the WLB. The Communications Station will be transmitting on one of the six designated DSC frequencies for the test, consequently they will probably have to utilize one of the HF-80 transmitters to transmit the signal. Power used should be that which would be normal for transmitting on the selected frequency. An appropriate length dot pattern should precede the DSC message to insure receipt by the scanner.

The WLB DSC system will have a scanner/receiver attached to the DSC modem. The Cubic R-3030 should scan the six DSC frequencies. It has the capability for the threshold on each frequency to be individually set. The Coast Guard's Electronics Lab at Station Alexandria, Va. has a DSC laboratory experiment and recommends initial settings on the Cubic R-3030 at full gain, negative 127dB threshold,

and 1/2 second scan time for each frequency. These are approximate settings and should be tested and modified if necessary during pre-test evaluation of the equipment.

VI. CONCLUSIONS, RECOMMENDATIONS, AND SUMMARY

A. SITOR

1. Use With Merchant Vessels

Communications with merchant vessels would be less costly if the use of SITOR for communicating with them was expanded, ultimately until the need for HF CW is eliminated. Table 3 clearly indicates that the majority of merchant vessels still rely on HF CW, for communicating with the Coast Guard. The author proposes that the Coast Guard, in concert with the maritime industry, establish a phase-out schedule for HF CW. Dates for the phase-out period could parallel those of the proposed IMO DSC phase-in. Vessels installing DSC equipment could shift their communications mode to SITOR simultaneously by purchasing modems with SITOR and DSC capabilities. Merchant vessels must also utilize the full automatic capabilities of SITOR and not wait for confirmation of receipt of messages from the circuit operator at the Communications Station.

However, careful attention should be paid to any potential negative effects such a requirement would have on the Automated Mutual Vessel Rescue (AMVER) system, which receives a lot of its information via HF CW through Coast Guard Communication Stations. It would be unfortunate if merchant vessel participation in this valuable Search and

Rescue tool declined because of the elimination of guarding HF CW at Coast Guard Communications Stations and/or the merchant fleet's unwillingness to shift to SITOR.

2. <u>Coast Guard Use of SITOR</u>

During the past few years, SITOR tests have been carried out in the Fourteenth, Ninth, and Seventh Districts. Each time, results have indicated the system is technically feasible, but there appears to have be n no follow-up. As per Chapter V, there is another test scheduled for the Fourteenth District late in FY-86. The test plan described in Chapter V will hopefully assist the Fourteenth District and participating units to conduct worthwhile, meaningful SITOR and DSC experiments. Upon conclusion of the tests, the Coast Guard should study the empirical as well as subjective results and make a determination whether or not SITOR will be used operationally on Coast Guard units. Consequently it is extremely important that the tests be conducted to the fullest extent possible. Assuming the test results indicate that SITOR should be utilized on at least some Coast Guard Cutters, several other factors must be considered.

a. Message Encryption

For SITOR to be a worthwhile primary or backup mode of record message communications, it must eventually have at least a low level encryption capability. Much law enforcement information is FOUO, and although normal SITOR

affords some degree of privacy through the use of Selcall numbers, in reality, anyone who desires will sooner or later be able to intercept and exploit SITOR communications. An encryption capability for SITOR would make it useful on all types of cutters.

b. Impact on Small Cutters

One of the points brought to light during the Seventh District test was the equipments technical complexity [Ref. 18]. The test platform was a 95 foot patrol boat which has no radiomen or electronics technicians attached. Consequently, the non-rated and junior petty officers who normally copy radio message traffic were unable to use it effectively. The system did work, but it seems as though there was insufficient operator training and planning between the units involved in the test. Prior to installing equipment such as SITOR on such units, there are several important factors to be considered:

- Maintenance and Support Philosophy - Will the Coast Guard or a contractor provide spare parts and maintenance support? If the unit is deployed away from its home port will there be people available for maintenance? Without proper support, no system will perform as advertised.

- Statement of use - The users must know exactly how the equipment is to be used. All participants must know their part, and how lack of support on their part will affect the system.

- Weight and space considerations: Many smaller cutters are weight and/or space critical. Will the new system upset this balance?

- Initial system costs - It must be determined whether the initial, support, and maintenance costs associated with the new system are worth the capability received. Would spending the money in another area to help the unit be more beneficial?

- Affect on personnel - How will the new system effect the people on board? Will it aid them in performing their duties or will it make them more difficult?

There are many other factors which might be considered, but in the author's opinion, the above five are the critical ones, and at a minimum should be studied before installing any new system on a cutter.

B. DSC

In accordance with IMO's present schedule, the final implementation of DSC is about 11 years away. As the first compliance date approaches, the Coast Guard will have to install DSC equipment at all units guarding any VHF, MF, or HF distress circuits. This will require, until 1997, the Coast Guard to monitor the present distress frequencies plus the new DSC ones. The author feels that the Coast Guard should follow IMO's schedule. Earlier initialization of the DSC system will require an expenditure of funds for the system and support costs sooner than required. Given the time value of money, and the general downward trend in prices of electronics equipment and the probable lack of DSC equipment on vessels, that money can better be spent elsewhere.

On the other side of the schedule, the Coast Guard must resist any pressure to guard present distress frequencies past the final DSC implementation date. Continued monitoring of those frequencies will cancel the potential personnel savings described in Chapter IV.

C. Summary

This thesis provides the reader with an understanding of DSC and SITOR communications and how they will or could effect present day cutter communications. A test plan is proposed to assist the Fourteenth Coast Guard District in conducting SITOR and DSC tests. Finally, it has presented some of the author's observations and opinions concerning the use of DSC and SITOR in the Coast Guard.

Appendix: SITOR and DSC Test Data Sheets

This Appendix contains the Data Sheets for the DSC and SITOR test plan detailed in Chapter V. They are as follows:

- Data Sheet 1 for SITOR test - Communications Station
- Data Sheet 2 for SITOR test - WLB
- Data Sheet 1 for DSC test - WLB
- Data Sheet 2 for DSC test - Communications Station

DATA SHEET 1 FOR SITOR TEST - COMMUNICATIONS STATION

DATE - ________ SUNRISE/SUNSET - __________

SCHEDULED TEST TIME	MSG DTG	MSG TYPE	MODE	TRANSMIT FREQUENCY	TOD
0100Z		test/actual	ARQ		
0130Z		SITOR BCST	FEC(C)	SITOR	
0300Z		test/actual	ARQ		
0330Z		SITOR BCST	FEC(C)	SITOR	
0430Z		SITOR BCST	FEC(C)	SITOR	
0600Z		test/actual	ARQ		
0630Z		SITOR BCST	FEC(C)	SITOR	
0730Z		SITOR BCST	FEC(C)	SITOR	
0830Z		test/actual	ARQ		
0930Z		test/actual	FEC(S)		
1030Z		test/actual	ARQ		
1130Z		test/actual	FEC(S)		
1300Z		test/actual	ARQ		
1330Z		SITOR BCST	FEC(C)	SITOR	
1430Z		test/actual	ARQ		
1600Z		test/actual	FEC(S)		
1700Z		test/actual	ARQ		
1730Z		SITOR BCST	FEC(C)	SITOR	
1900Z		test/actual	ARQ		
2000Z		test/actual	FEC(S)		
2030Z		SITOR BCST	FEC(C)	SITOR	
2200Z		test/actual	ARQ		
2230Z		SITOR BCST	FEC(C)	SITOR	
2359Z		test/actual	ARQ		

DATA SHEET 2 FOR SITOR TEST - WLB

DATE - ________ SUNRISE/SUNSET - ____________

SCHEDULED TEST TIME	MSG DTG	MSG TYPE	TIME OF RECEIPT	NR CHAR/ ERRORS	SHIP'S POSITION
0100Z		test/actual			
0130Z		SITOR BCST			
0300Z		test/actual			
0330Z		SITOR BCST			
0430Z		SITOR BCST			
0600Z		test/actual			
0630Z		SITOR BCST			
0730Z		SITOR BCST			
0830Z		test/actual			
0930Z		test/actual			
1030Z		test/actual			
1130Z		test/actual			
1300Z		test/actual			
1330Z		SITOR BCST			
1430Z		test/actual			
1600Z		test/actual			
1700Z		test/actual			
1730Z		SITOR BCST			
1900Z		test/actual			
2000Z		test/actual			
2030Z		SITOR BCST			
2200Z		test/actual			
2230Z		SITOR BCST			
2359Z		test/actual			

DATA SHEET 1 FOR DSC TEST - WLB

DATE/TIME	SHIP'S POSTION	EMPLOYMENT	FREQUENCY	#CHAR/ ERRORS

DATA SHEET 2 FOR DSC TEST - COMMUNICATIONS STATION

DATE/TIME TRANSMITTED	FREQUENCY	# CHARACTERS

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